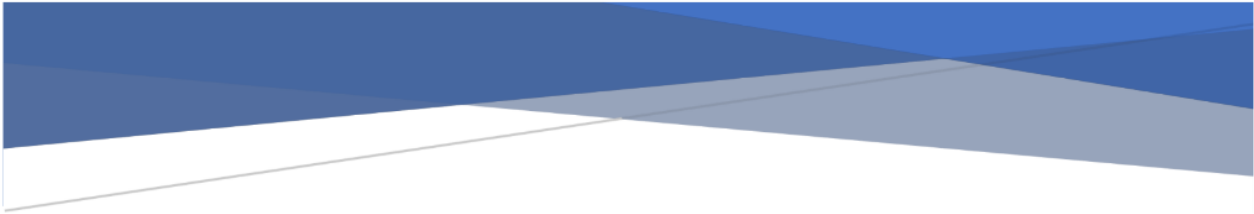


# ACDA5010 - Principles of OME Assignment - 1810347

*by* Christopher Peacock

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| SUBMISSION ID  | 131444940                                                                                                   | CHARACTER COUNT | 16078 |



# PRINCIPLES OF OME

ACDA5010

## [Abstract](#)

This report details the investigation into the design and test requirements for a blast/fragmentation bomb.

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## Introduction

This report investigates the design and testing considerations for a guided blast and fragmentation bomb which is required to target a building.

All bombs are designed to be dropped from aircraft and can have different effects on targets depending on what the target is and the design of the bomb. Different types of aircraft can have different effects on the bomb in flight and the effectiveness of the bomb will depend on the type of target, its armour or protection and whether it is above ground or subterranean. This report will detail the considerations needed in designing a bomb.

Consideration was given to the requirements, the design considerations, the testing required, its in-service life and its disposal. Any munition which is being designed will need to be capable of inflicting the damage required on the target at a suitable range, be able to be launched or dropped when required and be safe to store, handle and use. [1, p. 12]

## Target

The construction of a target building is the primary consideration for the design of a munition. The design considerations for a bomb whose target is underground will be different to targets which are hardened or above ground. Some of the main characteristics which are relevant to the target are the following:

- The number of targets and how they are dispersed
- How vulnerable the targets are. They may have protection such as camouflage, armour or other defences [1, p. 16]
- Whether the target is moving
- How visible the target is in both the visual and non-visible (IR or radar) spectrums [1, p. 14]

The effect which the bomb has on the target has a large impact on the design of any munition. The considerations are whether the building is to be destroyed or whether personnel and equipment within the building are to be targeted.

For the purposes of this report the type of building which the bomb is designed to target is an above ground structure of a six-inch-thick concrete construction, such as a hardened aircraft shelter. The primary focus will be to target personnel and equipment within the structure.

## Carrying aircraft

The aircraft which carries the bomb will impact on the design of any munition which it carries. The primary aircraft types which carry bombs are helicopters, sub-sonic turboprop or jet aircraft and supersonic fast jets. Each of these aircraft types have different impacts on munitions when in flight. Munitions on helicopters are subjected to large amounts of vibration. [2, p. 10] Large amounts of sustained vibration can result in cracks in warhead and propellant fills. When an aircraft is in flight heat is generated on the leading edges of the aircraft and any munitions on hard points underneath the aircraft's wing. As the front of a bomb is heated the heat can be transferred through the bomb casing into the explosive fills. On repeated missions the heating and cooling of the fill and the expansion and contraction resulting from this can lead to cracks in the fill and gaps between the fill and the casing. Cracks in the fills can cause hot spots which may result in the unintentional initiation of the bomb, especially when exposed to acceleration forces, heating and G force. [3, pp. 6-7]

As a result of the potential for cracks to form in the fills munitions have a limited lifetime on an airframe before they require non-destructive testing or refurbishment. [2, p. 10] In order to mitigate the heating of a bomb on an aircraft's wing, some aircraft have internal bomb bays which prevent the heating of the bomb.

For the purposes of this report the aircraft which this bomb will be designed for will be a fixed wing, sub-sonic aircraft.

## Design

The requirement is for a bomb which is designed to target personnel and equipment within an above ground building of a 6-inch concrete construction and be mounted on a fixed wing subsonic aircraft. In order to effectively target personnel and equipment within the building a bomb must be capable of penetrating the structure of the building and detonate inside. In order to target personnel and equipment a combination of blast and fragmentation effects are required.

## Components

The key components for an aircraft bomb are as follows:

- Bomb casing
- Explosive fill
- Guidance and stabilisation
- Fuze
- Aircraft connections

### Bomb casing

The casing of the bomb needs to be a strong material to prevent the distortion of the bomb case as it penetrates the target building. In order for it to produce an effective fragmentation effect in the target building the case will need to be brittle enough to fragment when the bomb is initiated. [4, p. 14] A material such as steel would provide strength in the case but allow for good fragmentation effect. To improve the fragmentation effect of the bomb the case could be constructed with preformed fragmentation which would give a predictable spread of fragmentation. [5, pp. 6-8]

In order to determine the velocity of the fragmentation the Gurney theories are used. For bombs the closest approximation is the cylindrical theory. [6, pp. 385-394]

$$\frac{V}{\sqrt{2E}} = \left( \frac{M}{C} + \frac{1}{2} \right)^{-1/2}$$

V: Velocity of the fragment

$\sqrt{2E}$ : The Gurney constant of the explosive

M: The mass of the case

C: The mass of the explosive charge [6, pp. 385-394]

In order to allow penetration of the target building the nose of the case will need to be thicker than rest of the bomb. This would also have the effect of reducing the impact of heat on the bomb case. The bomb case will need to have sufficient environmental protection to prevent water ingress and the effect of salt water etc if being used in the maritime environment.

The shape of the bomb will impact on the aerodynamics of the bomb. If it is not streamlined, then it is more likely to become unstable and tumble in flight. It would also increase the drag on the aircraft when mounted onto the wing, reducing its speed and manoeuvrability.

The fill port of the bomb is likely to be at the base of the bomb. This is because it will allow the explosive fill to be poured correctly into the case.

### Explosive fill

In order for an effective fragmentation pattern to be formed the explosive fill will need to have intimate contact with the bomb's case or a bitumen liner. There are two methods for filling explosive articles, pressing and cast filling. Pressing a fill is usually done with explosives such as RDX or HMX on

small systems such as anti-tank missiles. Pressing a fill can leave areas of different density throughout the fill and has an increased potential for voids and gaps between the fill and the case. These voids can create hot spots and result in unintentional initiation of the bomb. [3, pp. 6-7] Cast filling is usually done with TNT mixtures of TNT. The fill is poured into a case which allows for an even density and intimate contact between the fill and the case.

Although RDX and HMX would be a better explosive to use their high melting points, 192-204°C and 275-280°C respectively [7, pp. 49-50], mean they are unsuitable for use as a cast explosive. TNT has a relatively low melting point, 80.7°C [7, p. 45] and as such is widely used as a cast explosive. Adding aluminium to the mixture will increase the blast of the explosive. [8, p. 6] The ideal explosive for this bomb would be a TNT, RDX, aluminium mixture.

#### Guidance and stabilisation

In order to ensure the bomb hits the target accurately it will require guidance and stabilisation. Stabilisation of the bomb is possible by the addition of fins to the rear of the casing as this will prevent tumbling of the bomb on release. Guidance of the bomb can be done in a number of ways from laser, radar and GPS guidance systems to releasing the bomb in a ballistic arc onto the target. [1, p. 3] Laser, GPS and other guidance systems require control surfaces to direct the bomb onto the target. These can be on the tail fins, canards, lateral thrusters, thrust vectoring or a combination of these. [1, p. 58]

#### Fuze

In order to initiate the bomb at the correct time the fuzeing and arming of the bomb is key. Fuzes can be proximity, delay or contact fuzes. [1, p. 70] As the bomb will be required to detonate inside a building a fuze which initiates on contact with the building is not suitable, so a delay is required. The fuze will also require safety features to ensure it is not armed close to the aircraft where an accidental detonation could damage the aircraft. The location of the fuze on the bomb will also impact on the performance of the bomb.

Safety features on the fuze can include clockwork mechanism, pyrotechnic delays and electronics or a combination of each. Setback and spin detents will not be suitable as the bomb will not experience this in flight. A fuze located at the nose of the bomb may suffer damage as a bomb travels through the target building so a fuze pocket will be required in either the rear or on the side.

#### Aircraft connection

In order for the bomb to be connected to the aircraft a connection points, both mechanical and electrical, are required. If the fuze has an electronic component or the bomb has a guidance unit attached, an electrical connection between the bomb and the aircraft will be required in order to provide power prior to launch and to allow arming commands to be sent. The simplest of mechanical connectors is round eyelets welded to the bomb case which can fix to the release mechanism on the aircraft.

## Testing

The bomb will require testing throughout its life both through the design stage and its service life.

### Design tests

The testing which will be required through the design stages can be physical testing of the bomb and simulations.

### Simulations

Simulations allow testing to be undertaken in the design stage of a system and the effects of changing design aspects to be determined without physically manufacturing items. Some of the aspects which can be varied include different materials, explosives case thickness and designs.

Modelling of the blast and fragmentation effects of the bomb can be undertaken using computer modelling software. This is required in the design stage, prior to manufacture to identify any likely anomalies within the design and to ensure it meets the design requirements. Modelling can also determine the impact of vibrations of different strengths and durations on the bomb, simulating the conditions it will experience when on different aircraft types.

In order to ensure the designed munition will be able to penetrate the target building finite material analysis can be undertaken on the bomb against different target materials and thicknesses. This will indicate whether the bomb would penetrate the target and help to identify whether the bomb case will be deformed either on impact or on its path through the target.

As the bomb will need to accurately hit the target its path through the air from launch to impact can be modelled. This is necessary, especially in modern aircraft, for targeting computers to ensure the bomb is released at the correct moment. Varying factors in this can be the shape and mass of the bomb, the speed of the releasing aircraft, wind and air density.

All of these tests will take place throughout the design stage of the bomb in order to ensure it meets the customer requirements. Failure to do this can result in increased costs from multiple design changes and ultimately a system which doesn't work.

### Physical tests

Physical testing on munitions will tend to occur towards the end of the design process to prove concepts and simulations.

The various explosives within the munition and the fuze will require testing to determine their sensitivity and sensitiveness and identify the associated risks and the ease of initiation. [9, p. 3] It is also necessary to determine whether there are any reactions, long and short term, between the explosives and any of the inert components within the bomb. [9, pp. 19-20]

The fuze will require testing to ensure it functions at the correct time and doesn't accidentally initiate. Testing on this may include testing of the safety and arming features, exposure to environmental factors such as static and electromagnetic radiation and how it responds to heat cycling or vibration.

Arena trials of the bomb will allow the designer to prove the impact the bomb has on the target. A trial such as this will include instrumentation such as blast gauges to show the blast pressure when the bomb is initiated. Targets throughout the arena will show the fragmentation pattern of the bomb while other targets can show the penetration of the fragments at varying distances. Trials such

as this can also show the protection different protective equipment, such as body armour, can provide.

The bomb will require testing to show how it reacts to a number of different scenarios and experiences. These can include exposure to static, electromagnetic radiation, heat cycling, vibrations and being dropped. All of these are likely to be experienced throughout the life of the bomb and a failure to test how the bomb reacts to them may result in accidental initiation or a failure to initiate correctly.

Aerial drop tests will prove that the bomb is able to accurately hit the target and be able to penetrate the target building as per the customer requirements. These trials will need to be conducted of all aircraft platforms which it is to be used with and in a variety of different weather conditions.

All bombs which are produced will require testing after they come off the production line, whether they are being used for trials or operational purposes. In order to maintain the integrity of the bomb non-destructive testing (NDT) is required as this allows inspections to be undertaken without damaging it. These tests can include ultrasound on the empty cases to determine whether there are cracks within the case and X-rays of the complete bomb to identify cracks and voids within the explosive fill of the bomb. Failing to identify cracks in the bomb case can result in structural failures and cracks and voids in the explosive fill could result in hotspots when exposed to the stresses of an aircraft in flight.

#### In service tests

Heat cycling, transportation, vibrations from the aircraft and exposure to the forces experienced on an aircraft can cause cracks within the explosive fill or impact on the chemistry of the explosives in the bomb or the fuze. As a result, throughout the life of the bomb it will require testing of differing sorts to ensure it is still safe for use.

After a set number of hours onboard an aircraft, which is determined from the simulations, all bombs will need to be withdrawn from frontline service and undergo inspection. These inspections are likely to include NDT such as X-rays to determine whether there are any cracks in the explosive fill and whether it can remain in service.

It may be necessary for some of the explosive fill to be removed from the bomb for the explosive chemistry to be tested. In order for this to happen the bomb will either require a core sample or a section of the fill.

#### Packaging tests

The bomb will require packaging for transportation which will be required to undergo United Nations approved testing and to have an appropriate classification assigned to it. [10, pp. 6-7] The tests which the packaging will be required to undergo include drop tests, fire test and impact tests [10, pp. 15-21] and its reaction to bullets, fragmentation and shaped charges. [11, pp. 12-22, 2] As the packaging is not directly applicable to the design of the bomb further detail on the packaging tests is not included.

#### In service handling and storage

The storage and handling requirements of the bomb by the customer will be determined by the testing undertaken before it is given to the customer. This will be informed by the classification given to the munition by the ESTC. [10, p. 22] It will, however, need to be stored in a secure explosive

licenced premises which has a stable temperature. This will help to ensure there is no heat cycling, that they are protected, and the building can contain any accidental initiation. On completion of the service life of the bomb the fill can be removed from the bomb by means such as induction heating allowing it to be recycled. The bomb case, once cleaned and checked for imperfections, can be reused.

## Conclusion

The bomb which will be designed will have a steel case, thicker at the nose which will allow the bomb to penetrate the target and provide effective fragmentation within the target building. The fill will be a TNT/RDX/Aluminium fill as it is comparatively cheap, can be cast filled and can be easily extracted at the end of its life. The addition of RDX and Aluminium to the TNT increases the blast of the bomb whilst still allowing it to be cast. The guidance of the bomb will be controlled by the aircraft releasing it as a "dumb" bomb with a fin section at the rear of the case to stabilise it in flight.

It will require a combination of simulations and models throughout the design process to ensure the design is safe and will meet the customer requirements. Once the design phase is complete the bomb will require physical testing to ensure it is able to hit the target and deliver the effect on target which is required.

Throughout its life it will require in service testing and at the end of its life the fill is easily removable and recyclable.

## References

- [1] D. D. Bray, "Introduction to Guided Weapons Technology," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [2] L. C. L. Nelson, "Introduction to Ammunition and Lethality," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [3] D. N. Flood, "Introduction to Explosives, Initiation of Explosives," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2015.
- [4] D. J. Shackel, "Materials in Munitions," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [5] D. C. Couldrick, "Fragmentation Warheads," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [6] P. Cooper, "Acceleration, Formation, and Flight of Fragments". Explosives Engineering, Wiley, 1996.
- [7] J. Akhavan, The Chemistry of Explosives, 3rd Edition, Cambridge: RSC Publishing, 2011.
- [8] D. N. Flood, "Introduction to Explosives, High Explosive Formulations," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [9] T. Lawrence, "OME (I) Explosives Testing," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2014.
- [10] D. Brook, "Classification of MOD Explosives," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom, 2016.
- [11] T. Lawrence, "OME (I) Charge and Weapon Tests," in *Ordnance Munitions and Explosives Intermediate Course Notes*, Defence Academy of the United Kingdom.

# ACDA5010 - Principles of OME Assignment - 1810347

## GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

**Instructor**

68/100

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GRADING FORM: SMU GENERIC\_GJ

CHRISTOPHER  
PEACOCK

68

## RESEARCH-INFORMED LITERATURE

-  Good balance of munition, explosive and regulatory references **7**

## KNOWLEDGE AND UNDERSTANDING

-  "Good understanding of the topic. Includes service life and environmental tests. Even suggested use of modelling and simulation. Understands the trade off between performance and cost." **19.5**

## ANALYSIS

-  Sound, logical, analytical thinking; synthesis and evaluation. **19.5**

## PRACTICAL APPLICATION AND DEP.

-  A good appreciation of tools and techniques. Understood the breadth of trials required including environmental testing, and what too look for and mentioned QA activities that would be required on the production line to assure safe product. **15**

## SKILLS FOR PROFESSIONAL PRAC.

-  Report was well worded and clear, Can communicate

professionally and, confidently in a suitable format.